Space Weather Technical Forecast

Issued on Tuesday, 21 February 2023 at 01:10 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of M-class flares (R1-R2; Minor-Moderate radio blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate in the past 24 hours, with frequent mid-level C-class flares recorded at GOES 16, and one M-class flare at 20/1458UTC reaching M4.4 from a new emerging region in the far northeast, AR3234. The second largest of the aforementioned flares was C7.1 observed at 20/0702UTC from near the leading spot of AR3226 in the northwestern quadrant, with the spot group itself otherwise showing visual fading in its trailing portion, finishing the reporting period as a Cho/Beta. Nine active regions cover the visible solar disc and the largest and nominally most potent active region 3229 remains in the northeastern quarter of the disc, retaining a Eki/Beta-Gamma-Delta classification and some mobility in its central spots, including its tenuous delta. It is this particular region that was responsible for the CME shock arrival on the 20 February arising from the Strong-class flare of 17 February. Another noteworthy region remains AR3231 displaying a proliferation of trailing spots in the northwest, and this appears as Dso/Beta. Some newly numbered regions are on the disc and the most notable is AR3234, which is rotating across the northeastern limb and produced the M4.4 flare.
A 'prominence eruption' was observed from the southwest during the UTC afternoon of Sunday 19 February, erupting from near a sunspot in this location, AR3217 and this has a small chance of delivering a glancing interaction late on day 2 or early day 3 (Wednesday 22 or Thursday 23 February). No further significant CME events are earth-bound.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by DSCOVR and ACE at L1, started the period at slow-ambient levels before becoming slightly elevated following the arrival of the awaited shock from the 17 February X2.2-associated CME as of 20/0952UTC. This reached Earth-based magnetometers at 20/1045UTC, with BGS Hartland seeing a modest 15nT deflection in the H-component at this time. Solar wind density was also mostly in its normal Background range in single figures ppcc, but increasing to the high teens after the CME shock arrival. This was mirrored in a notable and ongoing increase in low energy protons at the ACE EPAM LEMS instrument. This tendency has been roughly mirrored at STEREO A in the PLASTIC instrument, with this satellite more in-line for effects given the expected fuller hit. Back at L1, the IMF showed a stable trend with a peak of 7nT, giving way to a new higher magnitude and a 16nT peak after 20/0952UTC. The north-south component was at mostly weak levels and varied between +/-5nT for much of the period, with a greater amplitude seen after the CME shock passed: -3/+10nT. The phi angle was mainly positive (away from the Sun) but with a few brief forays into a negative orientation (towards the sun). The net result of the above solar wind measures was for Quiet geomagnetic activity (Kp0-2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 remained at Background levels. High energy electron flux (greater than 2MeV) at GOES16 was at largely Normal Background levels. The associated 24-hour electron

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fluence has been well below the Active (1e8 integrated pfu) threshold, reaching 7.68e6 integrated pfu at 21/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Low activity is expected, with a chance for further M-class X-ray flares and a slight chance of becoming High from any isolated X-class flares - the main risk being from AR3229 that has produced them in the recent past in the northeastern quarter of the Sun

Solar Wind / Geomagnetic Activity: Solar winds are slightly elevated following the muted shock from the 17 February CME. A decline is likely back to Slow levels during Day 1 (Tuesday 21 February). There is a very low chance of a further CME glance (from 19 February) later day 2 or day 3 (Wednesday 22 or Thursday 23 February), but this is currently not expected. In terms of recurrent fast solar wind sources (from persistent 'coronal holes'), a slight enhancement may arise from the HSS associated with CH77 by day 2 (Wednesday 22 February). Geomagnetic activity mostly at Quiet levels, perhaps becoming Unsettled to Active as the CH77 HSS arrives by day 2 (Wednesday 22 February), combined with any arrival of the minor glance from the 19 February CME, which could give a minor geomagnetic storm interval.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is most likely to remain at background levels, but with a slight chance of rising towards the S1 level, perhaps exceeding it if any larger flares occur.

High energy (greater than 2 MeV) electron flux may increase later in the forecast period in response to the fast wind enhancement, however this is low confidence. The associated 24-hour fluence is expected to remain below the Active threshold (1e8 integrated pfu).

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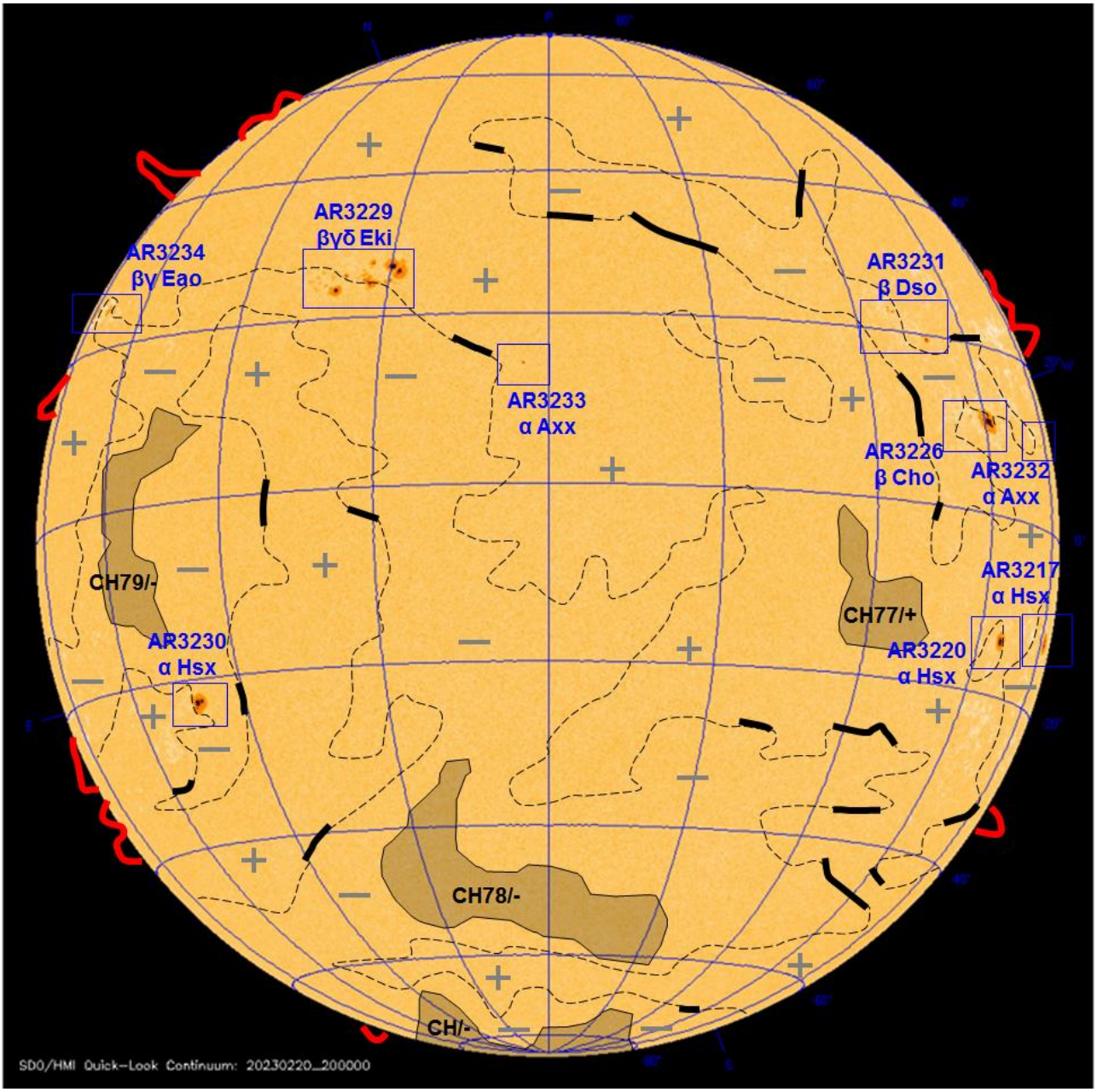
Figure 1. Solar Analysis Valid 2000UTC, 20 February 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A fast CME was observed on 17th with the X2.2 flare from AR3229. This is thought to be the event now seen passing L1 as of 20/0952UTC, reaching Earth-based magnetometers at 20/1045UTC with a 15nT deflection seen in the H-component at Hartland. This event was quite muted. In respect of other transients in the forecast, there is also a CME from a prominence eruption on 19 February, which is expected to most probably miss to the south and west (ahead of Earth), but may give a glancing interaction late on day 2 or early day 3 (Wednesday 22 into Thursday 23 February). The unperturbed solar wind forecast (i.e. coronal holes) is otherwise for a further enhancement from CH77/+ late day 1 or 2 Tuesday 21 into Wednesday 22 February). This is a persistent feature, although appears a little more ragged on imagery on this occasion. Furthermore, any enhancement is likely to be fairly muted due to its positive polarity and our approach to the (northern hemisphere) vernal equinox. Geomagnetic activity starts day 1 (Tuesday 21 February) mostly at Quiet levels, perhaps becoming Unsettled to Active as the CH77 HSS arrives by day 2 (Wednesday 22 February), combined with any arrival of the minor glance from the 19 February CME, which could give a minor geomagnetic storm interval. Thereafter Quiet to Unsettled levels are most probable.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	20	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
19/2320	Partial	Prominence near SR3217	SW limb	662 km/s	Probable miss	Some Enlil ensemble members suggest glance late 22 into 23 February.

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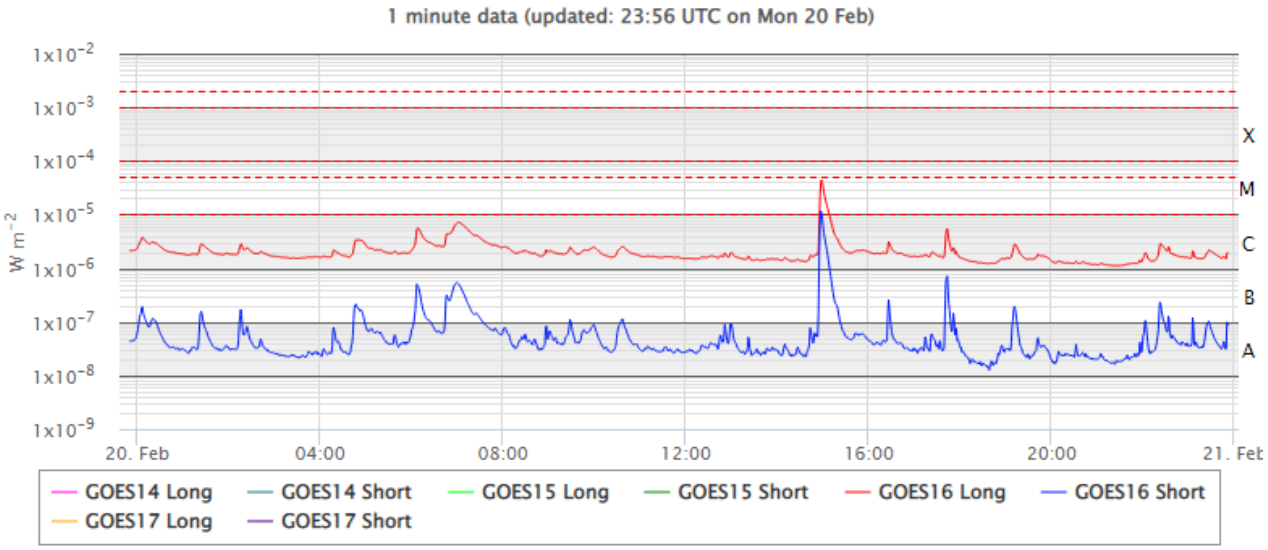
Radio Blackouts - X-Ray Flares:
Low solar activity is Expected. Isolated M-flares are Likely, with a Slight Chance of rising again to High with further X-flares - the main risk being from AR3229 in the northeast. The main focus of potential activity remains AR3229 in the northeastern quadrant. There has been a gradual eastward migration of its intermediate penumbral (with a possible delta) spots relative to the bulk of the group, with its overall area largely unchanged. This continues to present as an Eki/Beta-Gamma-Delta, which carries significant risks of flares based on the historical record, although the slowing growth trend, its evident maturity, and the fact that its magnetic looping is perhaps now a relatively straightforward arc between the leading and trailing groups on AIA171 - all serve to imply a decreased trend of Friday's events being repeated (X2.2-class flare).
The weight of sunspot groups is otherwise firmly in the western solar hemisphere, with up to five of the current (up to) eight sunspot groups departing the disc in the four-day period. In terms of arrivals, the northeastern limb has yielded another group, AR3234 (EAO/Beta-Gamma) with a CME observed in the past 24 hours which was last seen heading northeast on coronagraph imagery (to no presumed effect at Earth). This and perhaps another two returning regions in the southern solar hemisphere may slow any decline in the front side probabilities of significant flares, although the forecast trend is nevertheless downwards with time.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	40	30
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 2: X-ray flux at GEO with C-class flares and one M-class flare.



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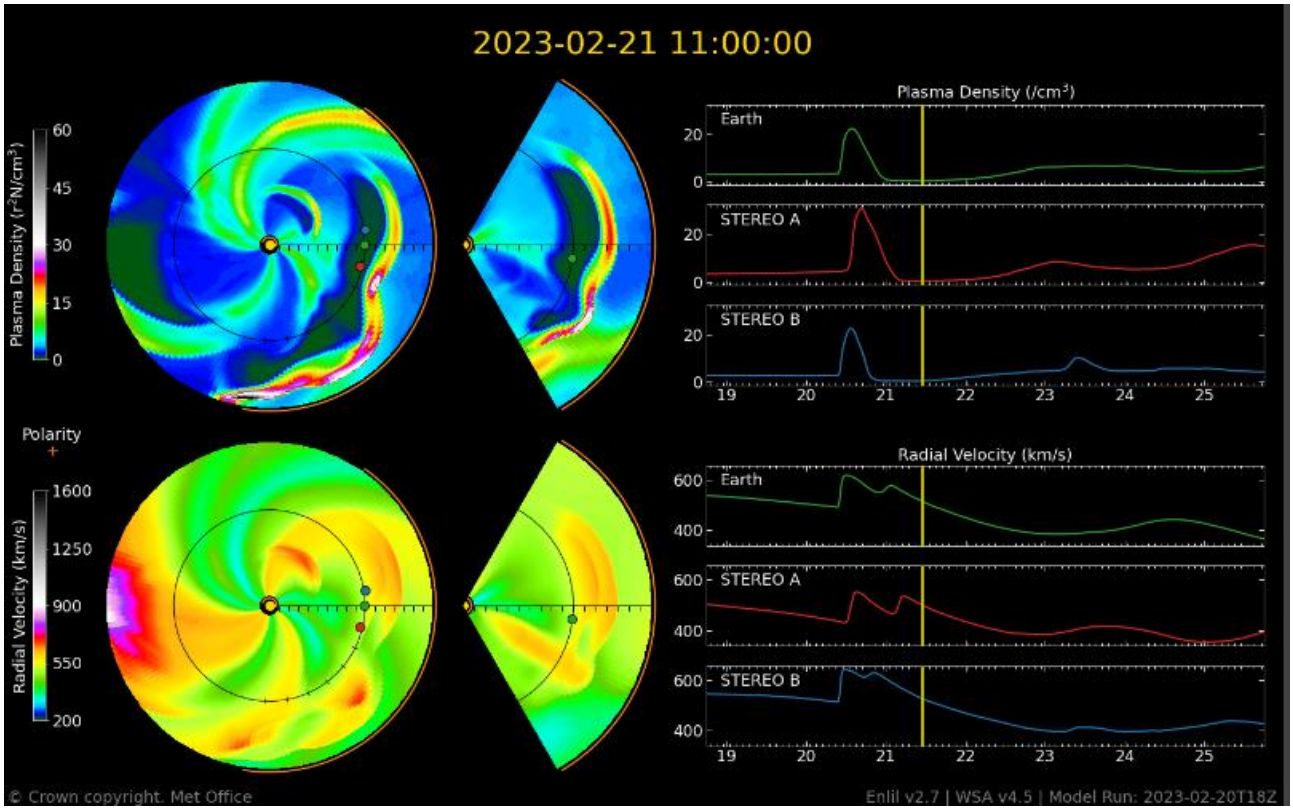
Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at Background levels. A proton response was not observed from the X2.2 flare on 17 February, however there remains a Slight Chance of further strong flares from this region. There are also a couple of spots in the western hemisphere that have the potential for M-class level flaring, which is a more favoured location for Earth-connecting proton events should they occur. This gives an ongoing Slight Chance of proton count rates breaching the S1 Minor Radiation Storm threshold.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 3: Met Office ENLIL output with CME receding from Earth.



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High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) observed at GOES16 is currently at Normal Background levels. Any more persistent increase in flux is now likely to be suppressed by geomagnetic activity arising from the 17 February CME incipient at Earth. Some recovery towards Moderate levels is then likely after the onset of the CH77 HSS, later day 2 or during day 3 (Wednesday 22 or Thursday 23 February), with a peak Slight Chance this may approach High flux levels by the end of the period.
The associated 24-hour fluence is expected to remain below the Active threshold, with only a Slight Chance of rising above later in the period. Met Office REFM output maintains below-Active fluence, and this is likely to be giving good guidance through the period, although the presence of transients (including the current event) serves to lower confidence somewhat.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	10	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: High energy electron flux and Met Office REFM output.

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